RESEARCH PRIORITIES

A vast body of research-based knowledge has been developed since selenium has been recognized as a major constraint in drainage water disposal. To some extent it is equally important to apply the research knowledge that has been developed to solve problems as to develop new research topics. This statement is not intended to imply that there are no further research needs. It is simply stated to emphasize that what we do know is equally important as to what we do not know.

The following broad topics are areas where additional research would be particularly useful in adopting the optimal management strategies. This report is not intended to be all-inclusive so any research topic not listed should not be apriori considered to be not important.

Drainage Outlet Control

Management to reduce drainage volumes is firmly recognized as a positive management option. Most research efforts on this topic have been directed towards irrigation management. In other words, controlling the amount of drainage water produced by controlling the amount of water applied.

Drain lines placed six or more feet deep are deeper than required to maintain water table elevation control. In other words, the water table does not need to be lowered to these depths to maintain crop production. Therefore, control on the drainage outlet is another means of reducing drainage volumes. Drainage outlet control in this report is used in the sense of placing a control on the drain line which can be opened allowing flow or closed preventing flow. In other words, an active process of managing drainage outlet and not merely placing a control whereby the water table level is raised before flow occurs.

As stated in other parts of this report, control of drainage outlet may have other potential benefits in addition to storing water in the profile, which may be used by the crop. Potentially hydraulic gradients are imposed which reduce the upslope to downslope water migration and increased downward migration of water below the field.

Possibly the greatest benefit, however, is that it provides a mechanism to remove the most amount of salt with the least amount of water from the root zone. Traditional leaching fraction concepts are based on steady state rather than the dynamic conditions which occur under irrigated agriculture. Water is extracted through the root zone reducing the soil water content and increasing the salt concentration. When irrigation water is applied, the flowing water transports the salt downward and restores the soil water content in the root zone with a fresh supply. This process flushes the salts to the bottom of the root zone and keeps a majority of the root zone free from salinity. There is no need for drainage if the irrigation simply resupplies the profile with the water lost through evapotranspiration between irrigations. This allows high concentrations of salts to result in the lower part of the root zone which can eventually be flushed out by a relatively small amount of water when the drain line is opened.

The above-described process can work as long as the irrigation water salinity is relatively low. It becomes less effective when using saline irrigation waters because the upper part of the root zone is exposed to the high salinity irrigation water.

The required research is more than engineering to develop the control systems. Nevertheless, this is a significant component of the required research. This is particularly true on sloping lands where control is required on individual laterals and possibly even on segments of laterals.

The research should be directed towards the total management practices. In other words, the above-stated processes for the continual flushing to the lower part of the root zone and monitoring techniques to determine when and how much leaching is required needs to be developed in a comprehensive total management package.

Extensive field research is required and therefore the budget requirements are sizable. Some components of the research can be accomplished in lysimeters. The dynamic computer model can be used to guide the experimental variables and monitoring needs.

Travel Times

Present models are adequate for simulating the consequences of different irrigation management practices on the amount of water and salt leaving the root zone. Improved analyses of the movement of water and salt after they leave the root zone is required to establish long term consequences. Specifically, long term projections on the salinity of water collected in drainage systems from a reuse system is important. As part of this analysis, it would be useful if the consequences were determined of having open or closed drain lines on hydraulic gradients and consequent stream lines of water flow in the saturated zone.

Because of the complex geologic system accurate quantitative projections cannot be reasonably expected. Nevertheless, reasonably accurate projected estimates are important in guiding policy decisions over short-term benefits and long-term consequences of agricultural drainage water reuse.

Economics

Numerous combinations of management options are available. Each combination of options invokes a set of costs and benefits. Additional economic analysis to identify the economically optimal combination of management is required for planning purposes.

Research on Boron

During our interviews, some individuals expressed that boron was going to be the limiting factor in the reuse of drainage waters and others who stated that boron is not an issue. These statements were made by reputable scientists which leads to the conclusion that additional research or at least interpretation of existing data is required to conclusively answer the question concerning boron hazard.

The difference in opinion appears to be based on two factors. The optimistic position is based on the interpretation that most boron tolerance coefficients that are reported are based on visual plant damage symptoms rather than yield. They argue that the plant symptoms develop with time and are not evident until the latter part of the growing season and may not significantly affect yield. Possibly a stronger argument that the optimists present is that more recent research identifies that the presence of salinity reduces boron damage. They propose that most of the early research on boron effects on plant growth were done in nonsaline solutions. It is conceivable that the salinity of drainage water will always be the limiting factor and not boron on the ultimate crop yield.

The more pessimistic view is that boron concentrations in drainage water exceed the published boron tolerance coefficients. Furthermore, boron is adsorbed by the soil and therefore is not readily leached through the soil profile as the other salts are. This phenomenon provides the opportunity for boron to accumulate in the root system more rapidly than salinity and eventually have its negative effect.

What is relatively well-known about boron is: (1) boron is taken up by plants and carried along the transpiration stream; (2) boron concentrates as water transpires; (3) highest boron concentrations occur in leaves at the end of the transpiration stream; (4) visual symptoms occur in zones of very high leaf tissue/boron concentration; (5) crops vary in boron tolerance; (6) increasing water salinity reduces toxic effects of boron and (7) boron is adsorbed by soil.

What is less known about boron is: (1) relationship between visual leaf symptoms and yield; (2) dynamic relationships between boron concentration in irrigation water adsorption of boron soil-solution concentration, boron uptake, boron effects on yield and the leaching of boron and (3) whether boron damage will ever exceed salinity damage when using saline drainage water.

The important information that is needed is to have boron tolerance coefficients related to yield rather than visual symptoms, and that the boron tolerance coefficients be evaluated as a function of salinity.

Soil Physical Properties

The hazard of destroying soil physical properties through the reuse of saline waters is well-recognized for most crops. The knowledge is far more limited in a cropping system of forages. Research to determine the effectiveness of forage root systems in protecting soil physical conditions when irrigated with drainage water is important.

Basic Salinity Tolerance Coefficients

Salinity tolerance coefficients are available for many crops. However, if any crop is contemplated to be used in a drainage reuse system for which the tolerance coefficients have not been established, it is important that they be determined. Although experiments can be run with these crops in a field experiment, the results are limited to the management variables used within the experiments. With the basic salinity tolerance coefficients, the computer model can be used to simulate the consequences of a wide range of management options which would not be practical on a field scale.

Reduce Ecological Hazards Associated with Using Evaporation Ponds

Except for ecological hazards evaporation ponds have many positive attributes for managing the salinity drainage problems in the Western San Joaquin Valley. Therefore, basic research to reduce the ecological hazard is important. Additional basic knowledge on selenium food chain transfers and ecotoxicological hazard is critical. This research might include the evaluation of brine shrimp or other invertebrate harvesting to interrupt the food chain. Initial studies reveal that brine shrimp harvesting might be ecologically and economically viable. Research to develop basic management practices conducive to high brine shrimp production is justified. This research may be directed toward developing a system to concentrate drainage water and then utilize the water for brine shrimp production.

Because selenium is the toxicant of concern, extended research to develop practical selenium removal methods is justified. The initial results of flowing water through hay bales to greatly reduce the selenium concentration is promising, but needs additional testing and refinement.